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NUCLEAR DETONATION

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OFF-SITE MEDICAL PLANNING AND MANAGEMENT FOR AN EXPERIMENTAL UNDERGROUND NUCLEAR DETONATION

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Abstract—The Bureau of Radiological Health, U.S. Public Health Service, provides comprehensive off-site radiological safety and medical programs for underground nuclear tests at the Nevada Test Site and for nuclear tests and experiments conducted at other geographical sites for non-weapons research and peaceful purposes. The specific physical requirements for these latter categories of use may preclude their being conducted at the Nevada Test Site.

Future underground nuclear detonations for research and peaceful purposes may be held in locations which are not necessarily remote from relatively sizeable civilian populations. It is thus desirable to delineate the particular problems and their management involved in the public health medical planning for population safety, including such aspects as evacuation.

These medical planning and management activities and their implementation for Project Sterling, a 350-ton yield underground nuclear detonation, which was conducted for seismic research purposes on 3 December 1966, in the Tatum Salt Dome near Hattiesburg, Mississippi, are described.

INTRODUCTION

ON 3 DECEMBER 1966, at 6.15 a.m. CST, a 350-ton yield nuclear device was detonated approximately 2700 ft underground in a subterranean salt formation known as the Tatum Salt Dome. This Salt Dome is located in Lamar County, Mississippi, approximately 19 air miles southwest of Hattiesburg (see Fig. 1).

This underground nuclear experiment was sponsored and funded jointly by the U.S. Department of Defense's Advanced Research Projects Agency and the Atomic Energy Commission (AEC) and was designated as Project Sterling. Project Sterling is a part of a seismic research program known as Vela Uniform being conducted by the U.S. Department of Defense

and the AEC. Project Sterling was designed to improve the capability of the United States to detect, locate and identify underground nuclear detonations. Project Sterling was the second nuclear detonation to be held at this site.^(1,2)

The Project Sterling nuclear device was suspended in the center of the spherical (110 ft dia.) cavity in the subterranean Tatum Salt Dome formed by the 5-kiloton yield Project Salmon nuclear detonation of 22 October 1964.^(1,3) Project Sterling was specifically designed to test the theory of decoupling; i.e. the reducing of the transmission of earth shock and the resulting long-range seismic signal by emplacement techniques.

The U.S. Public Health Service (PHS), through an agreement with the AEC, had responsibility for off-site radiological safety for Project Sterling. This off-site area was defined generally as that area within a 50-mile radius of surface ground zero,* excluding the area within a 2-mile radius of surface ground zero

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* Surface ground zero refers to the ground surface immediately above the shot point.

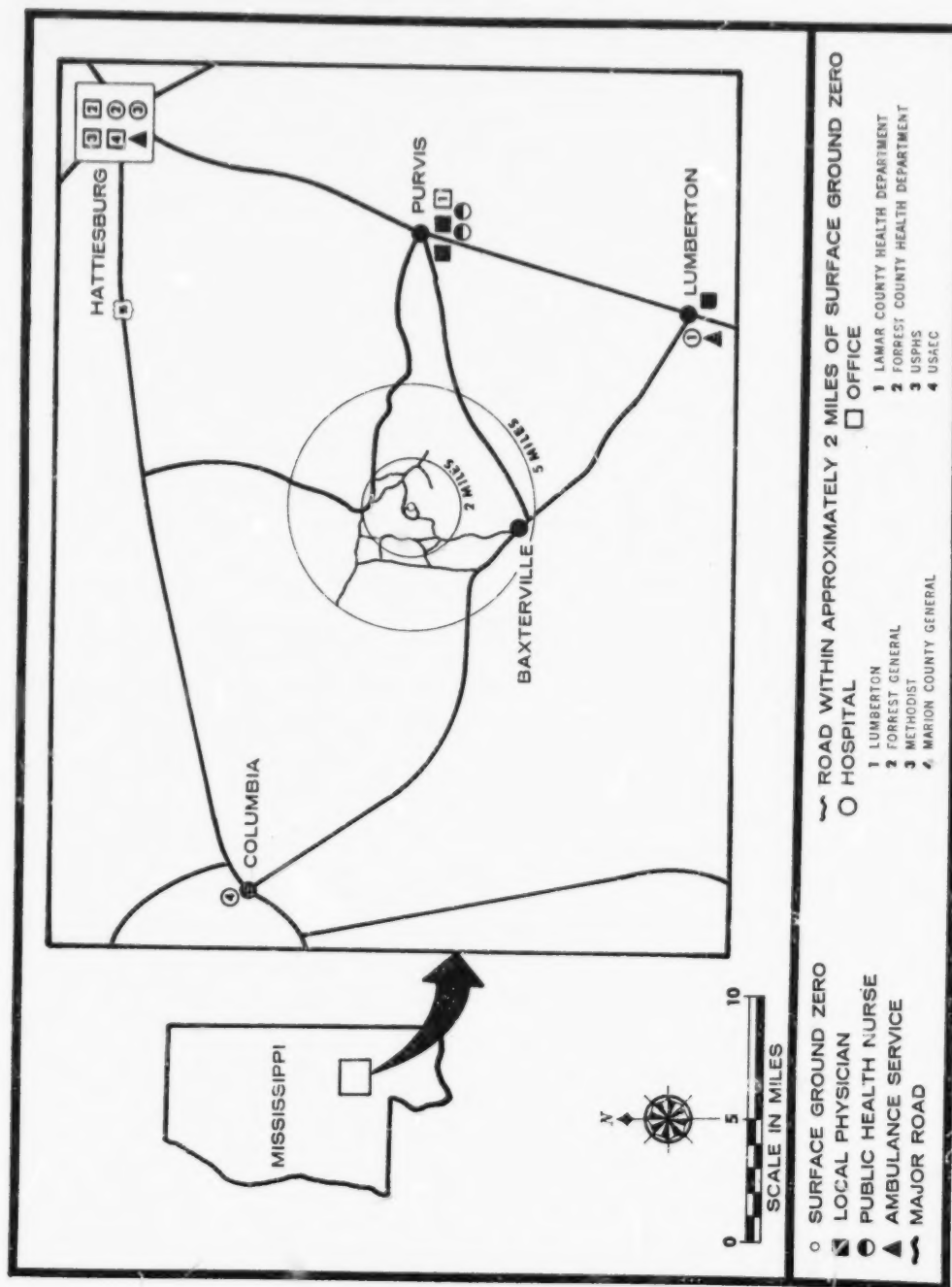


Fig. 1. Location map, Project Sterling.

Table 1. Underground nuclear detonations conducted external to the Nevada test site for the plowshare and Vela Uniform programs

Project designation	Location	Program	Type of geologic formation	Date of execution	Reference
Gnome	Eddy County, New Mexico	Plowshare	Salt	10 December 1961	4, 7
Shoal	Churchill County, Nevada	Vela Uniform	Granite	26 October 1963	8
Salmon	Lamar County, Mississippi	Vela Uniform	Salt	22 October 1964	1, 3
Longshot	Amchitka Island, Alaska	Vela Uniform	Basalt	29 October 1965	9
Sterling	Lamar County, Mississippi	Vela Uniform	Salt	3 December 1966	2
Gasbuggy	Rio Arriba County, New Mexico	Plowshare	Sandstone	10 December 1967	12
Rulison	Garfield County, Colorado	Plowshare	Sandstone	10 September 1969	13

designated as the "on-site" area (see Fig. 2), and as far beyond the 50-mile radius as deemed necessary.*

The PHS Off-Site Radiological Safety Program for Project Sterling was provided through the National Center for Radiological Health† by the joint efforts of the Southeastern Radiological Health Laboratory, Montgomery, Alabama, and the Southwestern Radiological Health Laboratory, Las Vegas, Nevada.

The PHS Off-site Radiological Safety Program for Project Sterling was designed on the basis of years of practical experience by the PHS in off-site management programs for nuclear detonations at the Nevada Test Site and the Pacific Proving Ground, and more recently at other sites. Important experience was gained at this Mississippi site during the October 1964 Project Salmon. The Radiological Safety Program for Project Salmon has been presented by CARTER and HARVEY.⁽¹⁾ Table 1 lists various underground nuclear detonations conducted external to the Nevada Test Site for the Plowshare and Vela Uniform

Programs. Additional information related to the Plowshare Program is available.^(4,10-13) These types of experimental tests have specific requirements, such as geology, geographically indigenous seismic activity, etc. Such diverse requirements can only be met by the utilization of sites possessing the necessary characteristics. In order to meet experimental criteria, it may be necessary to conduct certain underground nuclear detonations in locations which are not necessarily remote from relatively sizeable civilian populations. Obviously, public health and safety considerations have been, and will continue to be, given top priority in planning and conducting such experiments.

Two principal, potential safety problems are involved when an underground nuclear detonation is conducted in close proximity to human resident populations. These are ground shock and the release of radioactivity into the atmosphere (often referred to as "venting"). The former, if sufficiently severe, can cause structural damage to buildings and their contents, wells, etc. and could conceivably result in human injury by means of falling objects, flying debris, or by throwing people to the floor or ground.

By knowing the predicted yield, nature of the nuclear device, emplacement characteristics, geological features, and meteorological conditions, it is possible to estimate the maximum possible ground shock and maximum possible

* Predictions indicated that if a release of radioactivity occurred as a result of the detonation, the area within a 50-mile radius of surface ground zero would be the major area of interest, but the off-site program was designed to extend beyond this area, if necessary.

† In 1968, the National Center for Radiological Health became the Bureau of Radiological Health.

atmospheric release of radioactivity should "venting" occur. On this basis, necessary precautions are devised to protect the resident populace. These are summarized in Table 2.

METHODS

The major purpose of this paper is to present the Medical Program for Project Sterling in order to elucidate the medical and public health problems inherent in an underground nuclear detonation and their management.

The primary method for protecting the nearby populace could be designated as "selective area evacuation", i.e. the evacuation of geographical areas according to estimated risks and according to the practical consideration of time requirements for evacuation of such areas. In such an evacuation of a given populace, medical evaluation of certain residents is necessary. This is required because within any given population there may be illnesses and infirmities. It is therefore mandatory that merits of evacuating such ill persons exceed the risk involved in moving them. Then such an evacuation must be accomplished in a manner that the health of all evacuees is not jeopardized. In this sense the medical problems involved in planning for evacuating ill residents are no different than those which would, in general, be considered if, in the case of a natural disaster, one had sufficient time

to plan and implement an evacuation. In summary, an evacuation should:

- (1) effectively remove a resident populace from specific potential hazards,
- (2) conform to the criterion that the risk of moving all individuals should be less than that of the hazards avoided by evacuation, and
- (3) be conducted in the most careful, comfortable, and best manner available; and where illness is present, under medical supervision.

The initial step in preparation for evacuation was a continuing population survey, conducted by PHS Reserve Officers, beginning in mid-October 1966. This survey also served to inform the nearby residents of the plans for an underground nuclear test in the near future. Good public relations were established with these residents and they were generally pleased to have such a personal source of information and advice regarding the nuclear test. The survey determined that there were 1200 people residing in the 314 homes within a radial distance of 5 miles from surface ground zero and 39 persons with significant medical problems living within this region. Special measures would likely be required for medical care and transportation of many of these patients if evacuation became necessary. Therefore, it was necessary to evaluate the nature of each

Table 2. Protective precautionary measures for an underground nuclear detonation

-
1. Structural protection:
 - (a) reinforcement—bracing
 - (b) protective packaging—breakable items.
 2. Personal protection:
 - (a) thorough and continual radiation surveillance
 1. air—permanent air sampling stations
 - aerial (airplane) monitoring at time of detonation
 2. surface water and underground water
 3. vegetation
 4. milk
 5. personal film badge monitoring
 - (b) thorough and continual meteorological surveillance to predict travel of any cloud of radioactivity released
 - (c) population evaluation (number, geographical location, state of health)
 - (d) thorough briefing of residents
 - (e) evacuation of residents as necessary.
-

patient's problems in order to establish the comparative risk of evacuation. It was also necessary to establish where such patients should be taken in the event of evacuation and what care they should receive. For these purposes the PHS project medical officer(s) visited and became personally acquainted with all ill persons and their families living within a 5-mile radius of surface ground zero. They also became personally acquainted with all local physicians and health authorities.

The medical problems involved in planning for an underground nuclear detonation were explained, and evacuation plans were formulated with these ill persons and their families. Every possible effort was made to consider all personal needs and desires in the planning for this evacuation. Public Health Service personnel were specifically designated in advance to assist in evacuation of particular individuals. This assistance included personal contact to provide information on the scheduled evacuation and transportation, if required. General information on the project, including the evacuation effort, was disseminated by the local news media. In all cases the patients were asked to select their local physician(s) and hospital of choice as a source of medical care. They were advised that all such medical and custodial expenses incurred would be borne by the Federal Government, and, further, that they and all family members would receive appropriate monetary reimbursement for their participation. This reimbursement was based on current travel expenses and per diem payments allowed by the Federal Government.

It should be emphasized here that in no instance did the PHS project medical officer(s)

render any direct patient care. Such care was obtained as needed through the services of local and municipal medical personnel and facilities. The local health authorities were of invaluable assistance in this evaluation of patient's needs and conditions (Table 3). They also provided a source of continuously current information regarding changes in patients' conditions and new illnesses occurring within the area. Hospital administrators arranged to have their emergency facilities in a state of standby readiness at the time of the detonation. Local public health nurses voluntarily assumed a standby status at the time of the detonation. The locations of medical personnel and facilities utilized in the medical program for Project Sterling are shown in Fig. 1.

Table 4 summarizes the nature of the medical problems present among potential evacuees and Table 5 gives examples of the specific disorders encountered among the potential evacuees for Project Sterling.

On the basis of predicted maximum possible ground shock and maximum possible atmospheric radiation release, should venting occur, it was decided that all persons (127 people, representing 31 families) living within a 2-mile radius of surface ground zero be evacuated prior to detonation of Sterling device (see Fig. 2). It was further decided that all persons living within a distance of 2-5 miles from surface ground zero be on standby status for evacuation immediately following the detonation, if necessary. That is, if radiation monitoring systems detected the release of radioactivity from the test site, immediate steps would be taken to evacuate a windward sector out to a radial distance of 5 miles. In this

Table 3. Sources and types of local assistance in the evaluation and management of the medical problems found among a population of potential evacuees

- | |
|--|
| 1. State Department of Public Health—State Public Health Officer, or Deputy Officer. |
| 2. County Health Department—County Health Officer. |
| a. County Deputy Health Directors. |
| b. Public Health Nurses. |
| 3. Hospital administrators. |
| 4. Local Medical Associations. |
| 5. Local physicians. |
| 6. Local ambulance services. |
| 7. Hospitals and Clinics. |
| 8. Civil Defense Authorities. |

Table 4. Nature of medical problems encountered among potential evacuees

-
1. Possible problems—all medical problems known to occur in the area.
 2. Severity—all degrees possible, but usually of a degree compatible with home care.
 3. Onset—acute or chronic (usually chronic or convalescing from acute stage).
 4. Diagnosis—may or may not have been established.
 5. Treatment—may or may not have been obtained.
 6. State of movability—all degrees: ambulatory, ambulatory with restrictions, ambulatory with aid, confined to wheelchair, bedfast.
-

Table 5. Examples of medical problems encountered among potential evacuees for project sterling

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- A. Infectious
 1. active tuberculosis
 2. cystic fibrosis with chronic bronchitis and frequent episodes of pneumonia.
 - B. Cardiovascular
 1. myocardial infarctions—convalescent
 2. angina pectoris
 3. congestive heart failure, compensated (in varying degrees)
 4. peripheral vascular insufficiency—venous and arterial
 5. hypertensive cardiovascular disease.
 - C. Cerebrovascular
 1. cerebrovascular insufficiency
 2. strokes with or without major neurological deficit.
 - D. Metabolic: e.g. Diabetes Mellitus.
 - E. Pulmonary
 1. emphysema
 2. asthma.
 - F. Neurological and neuropsychiatric
 1. multiple sclerosis
 2. paraplegia
 3. mental retardation
 4. senility and deafness (associated with advanced age)
 5. severe anxiety—neuroses.
 - G. Musculoskeletal—severe arthritis and degenerative bone disease.
 - H. Miscellaneous
 1. pregnancy near term
 2. multisystem disease associated with advanced age
 3. convalescing from surgery
 4. bleeding peptic ulcers.
-

eventuality, residents would be contacted personally by PHS personnel who would make the necessary evacuation arrangements. It should be emphasized that various radiation monitoring systems located in the on-site area were employed to give advance warning of any escape of radioactive material into the atmosphere and to determine the quantity,

intensity, and direction of travel of any radioactive effluent arriving in the off-site area. This provision, in addition to the preliminary evacuation of all residents living in the off-site area within a 2-mile radial distance from surface ground zero, provided the necessary time interval required to evacuate a windward sector out to 5 miles from surface ground zero

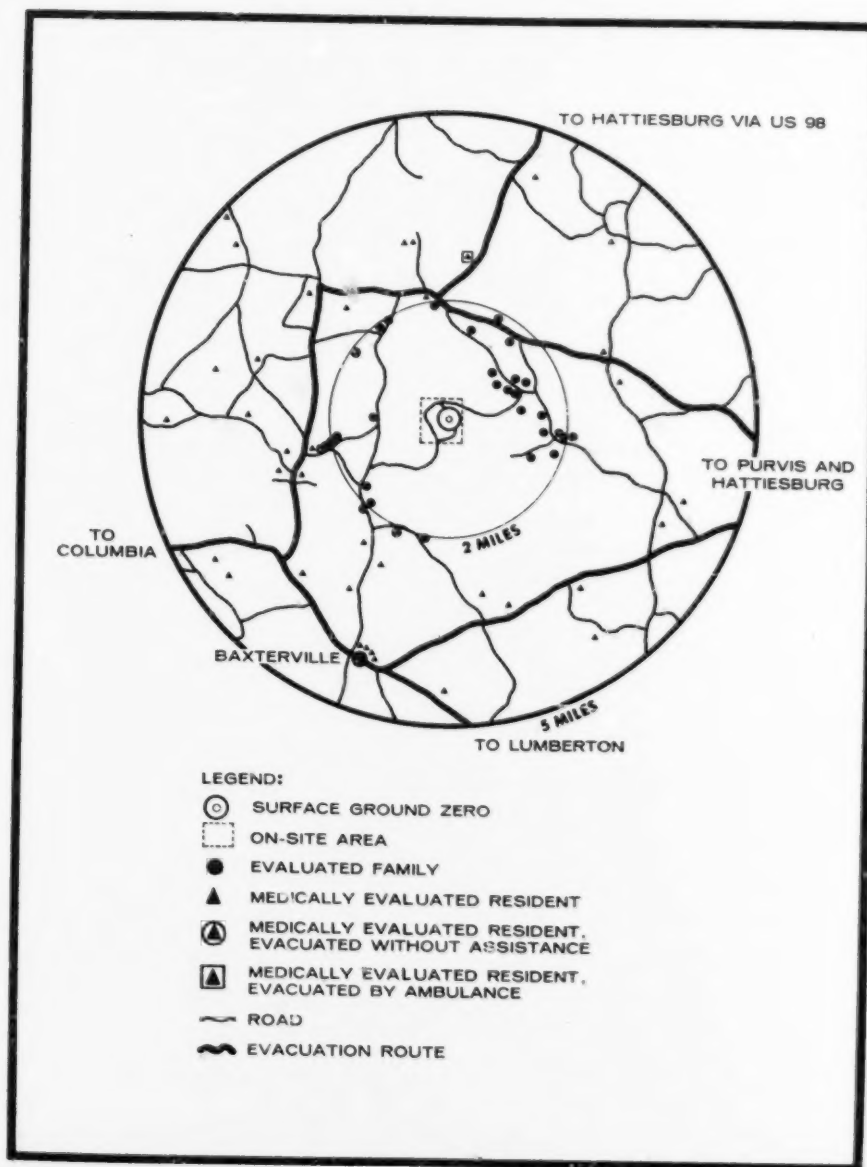


FIG. 2. Five-mile area map, Project Sterling.

before the arrival of any radioactive effluent cloud in that area. Various evacuation routes were identified and evaluated prior to the detonation such that, in the event of radioactive venting, a route leading away from the direction of travel of such a radioactive cloud could be utilized.

One individual living approximately 3 miles from surface ground zero was evacuated via ambulance on the day prior to Project Sterling. This patient was bedridden from the sequelae of a cerebrovascular occlusion suffered 2 yr previously. (He suffered neurological deficits or right hemiplegia, dysphagia and dysarthria. He was totally dependent on his family to care for and to feed him.) It was decided to move him on the day prior to the detonation rather than on the basis of indications immediately afterwards, because the nature of his condition precluded rapid movability (see Fig. 2).

All persons evacuated from the 2-mile radial region from surface ground zero were able to move without special medical assistance, and did so uneventfully and in an orderly fashion. All evacuees were checked out of and back into their homes by PHS radiation monitoring teams. It was thus verified that their homes were left secure (e.g. doors and windows locked, lights and stoves off, etc.) and that no hazard existed therein.

At the time of the detonation two ambulances were stationed at accessible positions in the potential evacuation area (see Fig. 2) to be available to assist in evacuation or in case of unforeseen events. An example of the latter would be automobile accidents involving either evacuees or personnel associated with Project Sterling. The ambulances were stationed at positions which were selected according to three criteria: (1) accessibility to the evacuation area, (2) population density, and (3) ease of alternate directional movability (i.e. the ability to quickly reach a patient needing emergency ambulance transportation and evacuate the patient to a source of medical care while simultaneously traveling in a direction away from the direction of travel of any radioactive cloud produced if venting has occurred).

The evacuation, ambulance movements, radiation monitoring efforts, road block

synchronization, and the post detonation safety evaluation and return of residents were coordinated by means of a short wave radio network assigned to the PHS. Thus, all ambulances, and PHS vehicles, radiation monitors, and surveillance aircraft were in continuous radio communication. Adequate and well-ordered communications are essential in such a complex operation.

After all residents were evacuated from the area extending radially 2 miles from surface ground zero, all access routes were blocked and guarded to prevent personnel from entering the temporarily evacuated area and to provide physical protection for the property in the area.

No detectable off-site escape of radiation or other accidents occurred in association with Project Sterling. Evacuation proceeded in an orderly fashion without panic, and individuals and family groups were promptly returned to their homes on a scheduled basis.

CONCLUDING STATEMENT

The medical experience gained during Project Sterling and its predecessor, Project Salmon, yields further evidence that underground nuclear detonations can be conducted safely in a relatively populous area if reasonable safety requirements are met and proper precautions taken. This is a matter of great importance to the utilization of the explosive energy of the atom for peaceful purposes, and must be achieved if real progress is to be made in harnessing the explosive power of the atom.

Medical problems in off-site radiological safety programs, including those associated with population evacuation, can be defined, planned for, and resolved by careful implementation of a program, which to be effective must be based on a good rapport with the residents, local officials, and the medical community.

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